Art. X.—*An Operculum from the Lilydale Limestone.*

(With Plate IX).

By R. Etheridge, Junr., Corr. Member.

[Read 14th September, 1893].

The opercula of Univalves are amongst the less common fossils met with in rocks of Upper Silurian age, but although known to occur in those of Europe, have not been described, so far as I am aware, from deposits of a similar nature in Australia. My acquaintance with opercula from the Lilydale Limestone was first made through the collection of Mr. G. Sweet, of Brunswick, and subsequently by means of collections made at Lilydale by Mr. A. J. North, on behalf of the Australian Museum, Sydney. These bodies were also casually referred to by Messrs. G. B. Pritchard and T. S. Hall* during the discussion on the Rev. A. Cresswell's paper† "Notes on the Lilydale Limestone." The observations in question will be referred to later.

The Opercula are disc-shaped, amphicœlous, strongly reminding one of the vertebral centrums of some fish. Those I have seen vary in size from half to once inch in diameter, and are bevelled from the exterior inwards along the sides. Further, they are thick solid bodies, almost equally concave, but the concavity less acute on the exterior, and more gradually inclined inwards than on the interior. The periphery of the latter side is flattened, the central area small, depressed, and circular, and often presenting a minute central nucleus. The thickness on the sides of the largest example I have seen is two-eights of an inch, or a trifle over; the thinnest, three-sixteenths of an inch. Mr. Pritchard informs me that he possesses examples of these opercula varying in size from one-sixteenth to one and a quarter inches in diameter, and from one-fiftieth to one-quarter of an inch in thickness. The structure is very apparent, even to the naked eye, the exterior exhibiting close concentric thread-

* Proc. R. Soc. Vict., 1893, v. (n.s.), p. 260. † *Ibid*, p. 38.

like lines, the edges of the component laminæ. Every here and there one is larger than the others. In sections prepared for the microscope, the concentric laminæ become very apparent, both in horizontal and vertical sections. The latter also display the outline exceedingly well. The opercula are practically round, a fact which can be easily ascertained by following the concentric laminæ in a transverse section. This point is an important one, as it may bear on the question of the identity of the operculum to its shell.

Mr. T. S. Hall mentioned in the discussion before referred to, that an operculum had been found "wedged into the mouth of an Euomphalus." Not having seen this genus amongst the Lilydale fossils, I am unable to follow the suggestion further, but must fall back upon the question—Do these opercula appertain to either of the described shells, *Oriostoma Northi*, or one of the *Cyclonemæ?* The mouth in the former is not, strictly speaking, round, but angulated towards the inner lip. On the other hand, *Cyclonema australis*, and probably also *C. lilydalensis* possess a round mouth, but this difficulty presents itself—the smallest operculum before me is too large for the largest *C. australis*. It is hardly necessary to consider such a form as *Phanerotrema australis*, that being a member of the Pleurotomariidæ, in which the operculum is corneous; but, at the same time, so far as mere size goes, the mouth of this species would far better accommodate a body of the size of these opercula than the shells mentioned above. If one may be permitted to surmise that the *Euomphalus* mentioned by Mr. Hall be *Oriostoma Northi*, then the matter narrows itself down to the question, is the operculum in such a position that it can be regarded as *in situ?* If on the other hand the shell be *Euomphalus* the matter becomes still more interesting. Let us now consider what previous investigations on Silurian opercula teach us.

Many years ago Dr. F. Smithe, M.A., figured* the well-known Wenlock shell, *Oriostoma sculptum*, Sby. sp., with its operculum *in situ*. The latter is plano-concave, plane without, concave within, formed of twelve concentric laminæ, and with a well-marked nucleus and bevelled edges; therefore, except in its

* Observations on the Opercula of some Silurian Gastropoda.—Proc. Cotswold Nat. Field Club.

section, remarkably like the opercula from Lilydale. In 1881 I figured* some of these bodies from the Carboniferous and Wenlock rocks of Great Britain, and the Wenlock of Gotland. Those from the English Wenlock occupy the mouths of *Oriostoma sculptum*, Sby., and are depressed-conical, circular bodies, bearing seventeen or more concentric rings. The other side is flattened near the margin and then rises at the centre into a low spiral eminence. Allowing for the state of preservation, and slight variability, these agree perfectly well with those figured by Mr. Smithe and also those now about to be referred to.

By far the most complete set of Silurian opercula figured, however, are those from the Wenlock rocks of Gotland, by Dr. G. Lindström.† He gives illustrations of those of *Oriostoma coronatum*, Linds., and *O. globosum*, Schl., besides a number of others not relegated at the time he wrote to their proper species. The whole of these are conical, in a greater or lesser degree, and are thus described :—"The operculum, *i.e.*, of the genus, is calcareous and solid, on the inner side smooth with a thick, elevated rim round the margins, outside conical, sometimes higher than broad, covered with a number of spiral coils, ornamented with exceedingly thin lines."‡ It will be at once apparent that the opercula from Lilydale differ from those of the Gotland molluscs in the entire absence of any conical outline ; on the contrary, they are flattened disk-shaped. Lindström figures one of the less conical filling the aperture. The variation in form is very remarkable, from a depressed conical, through a depressed roundly-conical, to an elongately-conical, or absolutely plug-shaped outline, much resembling some rifle bullets. At the same time all possess the flat or very slightly concave inner face, accompanied by the external concentric coils, the latter having a more or less subimbricating appearance.

The operculum of *Cyclonema* is thus described : — "The operculum is broadly conical, with some ten large coils outside, impressed by a shallow groove along their superior border, and streaked by oblique, transversal lines."§ Illustrations‖ are given

* Ann. Mag. Nat. Hist., 1881, vii. (5), p. 29.
† The Silurian Gastropoda and Pteropoda of Gotland, 1884. t. 17.
‡ *Ibid.*, p. 156. § *Loc. cit.*, p. 174. ‖ *Ibid.*, t. 17.

of the operculum of *C. striatum*, His., and of those of two other undetermined species. The general type is quite similar to that of this portion of the shell economy in *Oriostoma* as figured by Lindström. The Lilydale opercula more closely resemble those described by Smithe and myself from the Wenlock beds, than they do those from Gotland; at the same time, trivial differences which strike the eye on close examination, may ultimately prove of wider significance. The cross section of an operculum given by Smithe is most undoubtedly more akin to that of the Lilydale specimens than are any sections which could be derived from the Gotland examples. The latter are wholly plano-conical in section, Smithe's Wenlock operculum is certainly plano-concave, whilst the Lilydale forms, on the other hand, are either bi-concave, or slightly plano-concave.

It is possible that the shell spoken of by Mr. T. S. Hall as *Euomphalus* may throw some light upon this subject, and I should much like to be permitted to examine this specimen.

A strange similitude to some of these opercula is seen in a fossil from the Corniferous Limestone of Indiana, described by Mr. S. A. Miller as a sponge, under the name of *Cyclospongia discus*.* It is "circular, button-shaped or discoid, and consisting of numerous thin, calcareous laminæ, having a concentric structure and filled with minute canals or interstices." The upper surface is slightly convex, bearing numerous concentric lines, the under side slightly concave, with a "broad, undefined, shallow furrow near the circumference, and round depression in the centre." Were it not for the minute canals I should be much tempted to regard this object as an operculum.

I am indebted to Mr. C. Hedley, F.L.S., for the accompanying drawings.

POSTSCRIPT.

Through the courtesy of the Honorary Secretary of the Royal Society I have been permitted to add some additional information obtained since this paper was written, and kindly contributed by Mr. G. B. Pritchard. The latter informs me that he has in his

* Seventeenth Report Geol. Survey Indiana, 1892, t.l., f. 8 and 9.

possession examples of these opercula, varying from one-sixteenth to one and a quarter inch in diameter, and from one-fiftieth to a quarter of an inch in thickness, thus establishing the fact that they are both larger and smaller than the measurements previously given by me. He also informs me that in the collection of the Rev. Mr. Cresswell is a specimen of *Oriostoma Northi* with a similar operculum *in situ*, the shell about two and a half inches in diameter, and the operculum three quarters of an inch. Mr. Pritchard obtained a broken mouth of an *Oriostoma* at Lilydale, about five or six years ago, also with the operculum in its natural position. This was submitted to Professor Sir F. McCoy, and its nature determined by my eminent friend, who referred the fragment to *Euomphalus*. We have here the explanation of Mr. Hall's reference to the latter.

Mr. Pritchard's smallest *O. Northi*, a perfect young example, is half an inch in diameter, and yet is too large for the smallest of the operculums in his collection, whilst the largest specimen of this species is three and a quarter inches in diameter, with the operculum one inch in the same direction, so that the largest of the "lids" mentioned above (one and a quarter inches), seemingly indicates a very large example of the species.

These observations of Mr. Pritchard's will, I think, fairly answer my previous question as to which of the Lilydale shells our button-shaped bodies belong to. Furthermore, this additional evidence opens up the question—How far can the depressed Euomphaloid shells referred to *Oriostoma*, such as my *O. Northi*, and other similar forms, be properly placed in *Oriostoma?* Can they, with their amphicœlean opercula, be relegated to the same genus as those species so beautifully figured by Dr. Lindström, and touched on by Mr. Smithe and myself, with more or less conical opercula? It is a rather significant fact that all Lindström's figures showing opercula *in situ*, represent species with the more elevated spire, after the type of *O. discors*, Sby., *O. globosum*, Schl., and its var. *sculptum*, Sby., and not those with a depressed spire such as *O. rugosum*, Sby., nor those with a concealed spire (in a side view), like *O. augulatum*, Wahl. However, the subject is too long and complex to be considered now, and I hope at no distant date to communicate a paper to the Royal Society on the subject, and on the general family